Chapter 2
Entropy and Uncertainty:
Physics-Inspired Approaches to Risk Assessment in Finance

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ABSTRACT

This chapter examines how entropy and uncertainty, concepts rooted in physics and information theory, can be translated into innovative approaches for risk assessment in finance. Traditional financial models often rely on assumptions of normality, equilibrium, and linearity, which limit their ability to anticipate extreme events and systemic instabilities. By contrast, entropy-based methods provide tools to capture disorder, complexity, and hidden structures in financial data. The chapter situates these methods within a broader interdisciplinary dialogue, bridging physics, complexity science, and finance. Through conceptual discussion and illustrative examples, the authors argue that entropy not only enhances the quantitative description of uncertainty but also supports more resilient strategies for decision-making under incomplete information. Ultimately, the chapter aims to show how physics-inspired perspectives can enrich both theoretical models and practical applications in financial risk management.

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INTRODUCTION

The study of risk in finance has long been grounded in probabilistic reasoning, statistical inference, and econometric modeling. From the pioneering works of Markowitz (1952) on portfolio theory to the development of the Capital Asset Pricing Model (Sharpe, 1964) and Value-at-Risk frameworks (Jorion, 2007), risk assessment has largely been approached through tools that assume rational agents, normally distributed returns, and relatively stable market dynamics. However, the crises of the past decades—including the Asian financial crisis, the dot-com bubble, the 2008 global financial meltdown, and the COVID-19 pandemic—have exposed the fragility of such assumptions. Extreme events, nonlinear correlations, and systemic feedback loops have proven to be the rule rather than the exception in financial markets (Taleb, 2010). Against this backdrop, scholars and practitioners have increasingly turned toward alternative approaches capable of capturing the complexity, uncertainty, and emergent dynamics inherent to financial systems.

One particularly promising avenue of inquiry draws inspiration from physics, and more specifically from the concept of entropy. Originating in thermodynamics and later generalized in information theory, entropy provides a measure of disorder, uncertainty, or the lack of information in a system (Shannon, 1948; Jaynes, 1957). While physicists have used entropy to describe the dispersal of energy and the irreversibility of processes, economists and financial theorists have borrowed this notion to quantify unpredictability in markets, to evaluate portfolio diversification, and to identify hidden structures in financial data (Philippatos & Wilson, 1972; Maasoumi, 1993; Ustaoglu, 2018). Entropy-based metrics, unlike variance-based measures, are not constrained by assumptions of normality and can capture the richness of distributions, tail events, and systemic dependencies.

The concept of entropy was first introduced by Clausius in the mid-19th century as a measure of energy dispersal in thermodynamic systems. Boltzmann and Gibbs later extended this notion to statistical mechanics, framing entropy as a measure of the multiplicity of microstates compatible with a given macrostate. Shannon (1948) abstracted entropy into the domain of communication, where it quantified the uncertainty of information

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